

ZONE SELECTIVE INTERLOCKING (ZSI) APPLICATION AND TESTING GUIDE SIEMENS WL UL489 AND UL1066 AIR CIRCUIT BREAKERS

Definition: Zone Selective Interlocking (ZSI) - A method which allows two or more ground fault breakers to communicate with each other so that a short circuit or ground fault will be cleared by the breaker closest to the fault in the minimum time. The primary goal of ZSI is to switch off the fault current within the shortest possible time under consideration of full selectivity, regardless of the location of the fault.



For Siemens WL molded case circuit breakers, ETU745, ETU748, ETU755 or ETU776 trip units (above) are required for zone selective interlocking. Also, a ZSI CubicleBUS module is required for each circuit breaker that is integrated into the zone selective interlocking scheme (see image below).



In a typical zone selective interlocking system, each circuit breaker must be wired to all the other circuit breakers via the “ZSI In” and “ZSI Out” terminals (See Figure 1 below). In the case of Siemens WL circuit breakers these terminals are located on the ZSI CubicleBus module. In the event of a short circuit or ground fault, all circuit breakers communicate to determine and isolate the exact location of the fault, only the closest upstream circuit breaker will be opened.

Technical Data for the ZSI CubicleBUS Module

Operating voltage on the CubicleBUS minimum/maximum (V)	19.2/28.8
Current input from the CubicleBUS minimum/maximum (mA)	31/61
Automatic output reset after no more than	3 seconds
Shortest time blocking signal can be present at the outputs LV	100 ms
Standard trip time (including all delays)	Approximately 80 ms
Maximum number of circuit breakers connectable to ZSI IN	20
Maximum number of circuit breakers connectable to ZSI OUT	8
Maximum number of ZSI modules on one CubicleBUS	1
Power loss minimum/maximum (W)	0.8/1.76
Dimensions W/H/D (mm)	70/86/95
Weight (kg)	0.223
Temperature range (degrees C)	-20/60

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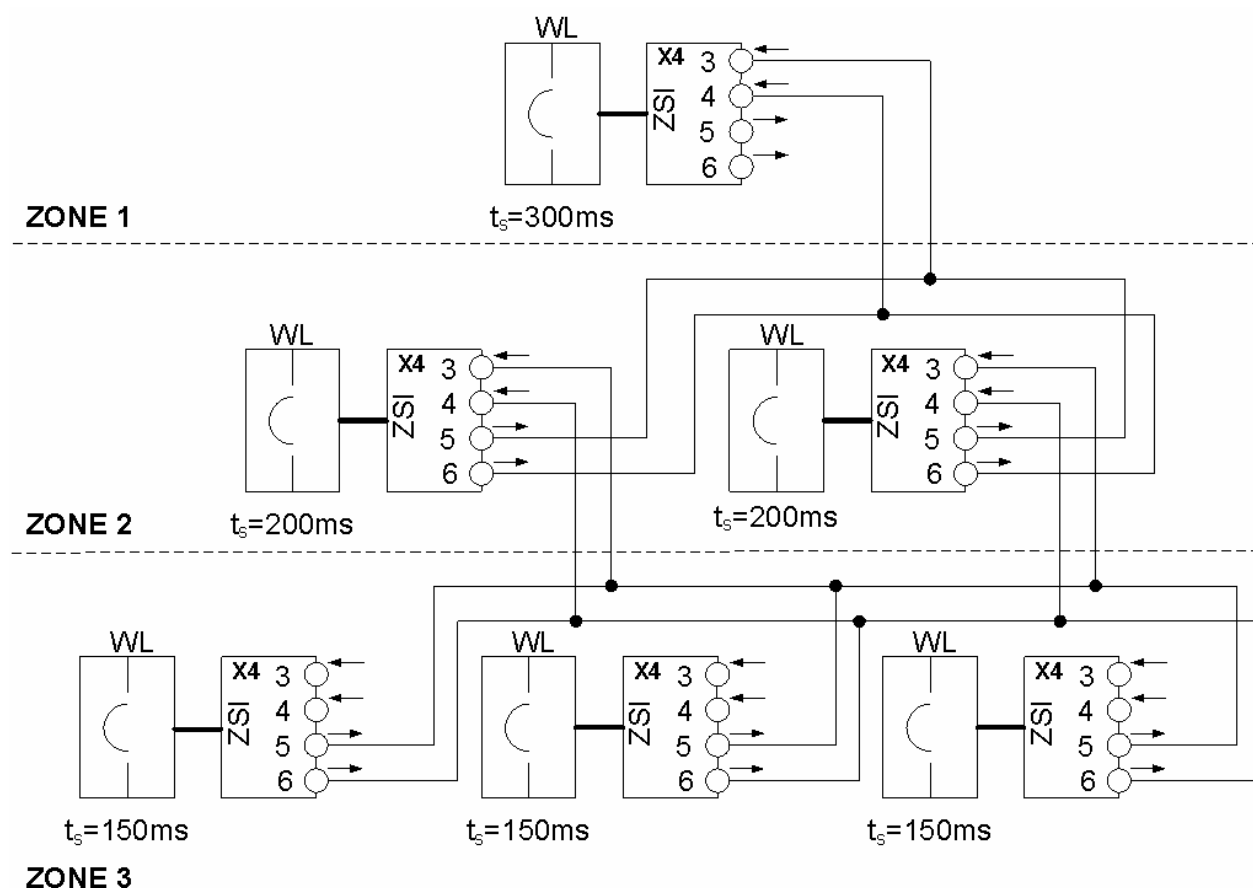


Figure 1. Typical WL ZSI Wiring Configuration

ZSI provides the complete range of selectivity with an extremely short delay time of 50ms maximum regardless of the number of fault zones and the location of the short circuit or ground fault in the power distribution system. The benefits of ZSI become more apparent with a higher number of fault zones which are typically found in large systems. By shortening the time to clear the fault, ZSI significantly reduces stress and damage in the event of a short circuit in the electrical apparatus.

If ZSI is used in a power distribution system comprised of several fault zones, each circuit breaker affected by a short circuit or ground fault interrogates the circuit breaker(s) directly downstream of it to ascertain whether the short circuit also occurred in the next fault zone below.

- If the short circuit or ground fault did occur in the downstream fault zone, the upstream circuit breaker delays tripping to ensure that the circuit breaker directly upstream of the short circuit or ground fault has enough time to interrupt the fault (by opening the breaker).
- If the circuit breaker(s) in the downstream fault zone do not report a short circuit or ground fault, the fault occurred between the two fault zones in question. In this case, one of the upstream circuit breakers interrupts the fault once the programmed delay time of t_{ZSI} (50 ms) has elapsed.

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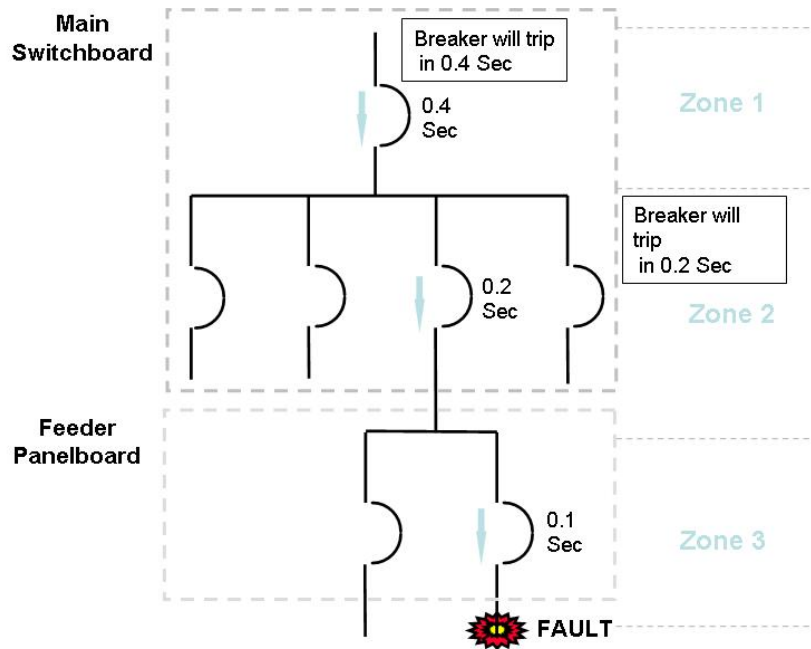


Figure 2. ZSI Example #1

In ZSI Example #1 (See Figure 2), the fault has occurred downstream of the feeder panelboard breaker located in Zone 3. Each of the circuit breakers with the blue downward arrow next to them establish that a fault has occurred. The feeder panelboard circuit breaker directly upstream of the fault sends an output blocking signal to the main switchboard feeder circuit breaker that feeds the panelboard confirming that the fault is actually downstream. A blocking signal is also sent to the main circuit breaker in the main switchboard. Since the feeder panelboard breaker does not receive a blocking signal from a lower zone breaker, this circuit breaker will interrupt the fault in 0.1 seconds, eliminating the need for any of the upstream circuit breakers to trip. If this breaker does not clear the fault, then the upstream breakers will trip according to their specific time delays (standard coordination without ZSI).

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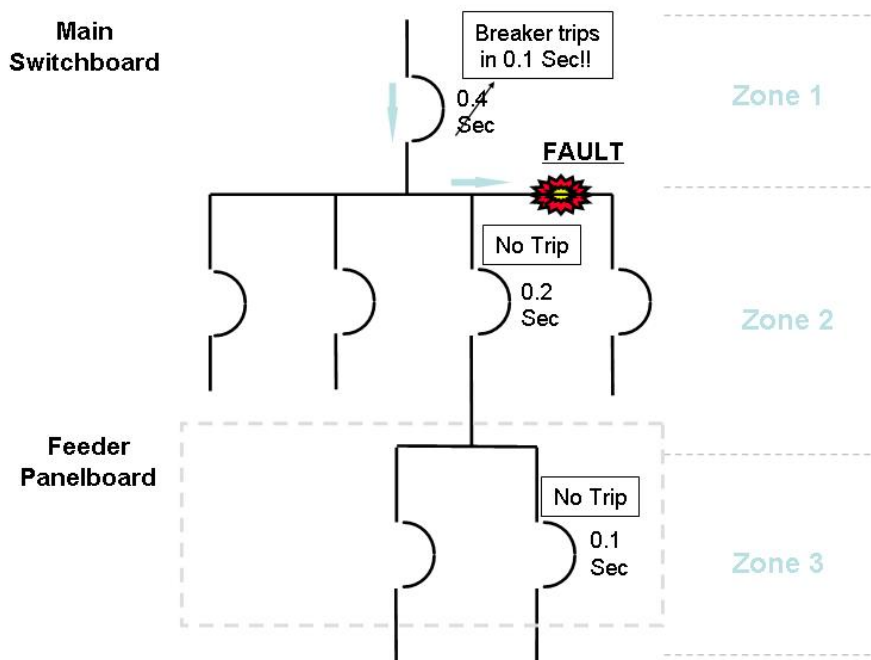


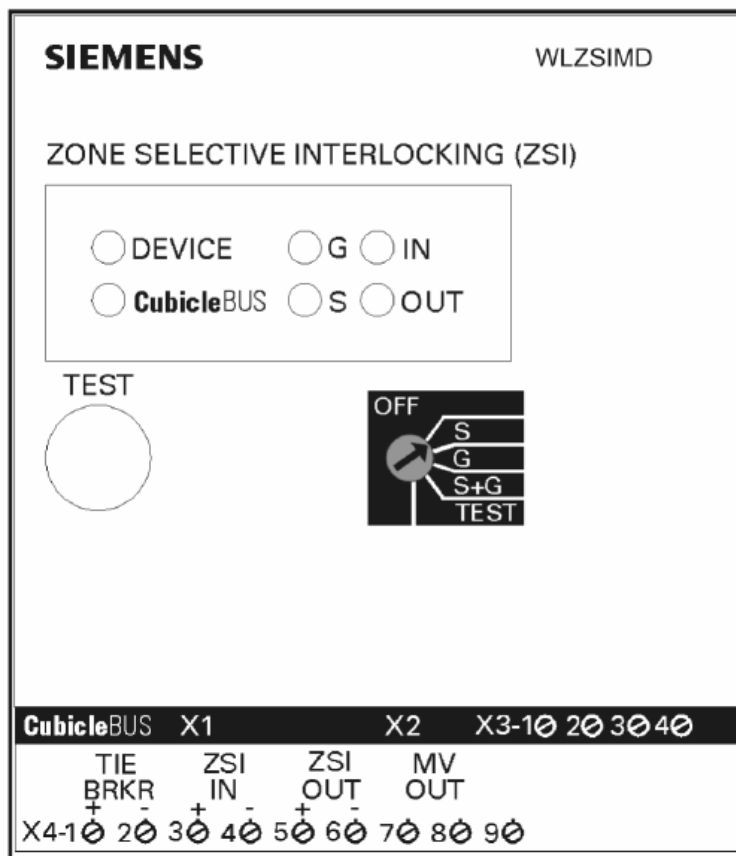
Figure 3. ZSI Example #2

In ZSI Example #2 (See Figure 3), the fault has occurred directly upstream of the main circuit breaker in the main switchboard (between Zone 1 and Zone 2). In this case, only this main circuit breaker establishes that a fault has occurred. No blocking signals are received from any of the downstream circuit breakers so this breaker trips in 0.1 ms instead of the 0.4 ms time delay that it is set for.

SPECIAL NOTES:

- The connection between the ZSI input and output terminals is established using a shielded twisted pair lead, which must be no longer than 400 meters for AWG 18 conductor diameter.
- Observe the specified polarity for ZSI IN and OUT connections when connecting: plus to plus and minus to minus.
- The ZSI module allows connection of up to 8 circuit breakers at the ZSI IN input and 20 circuit breakers at the ZSI OUT output.

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ZSI CubicleBUS Module Terminations

TERMINAL	CONNECTION
TIE BRKR	Used only for systems with tie breakers. Allows complete ZSI functionality in systems with tie breakers so that various energy flow directions can be taken into account.
ZSI IN	ZSI modules of higher fault zone circuit breakers
ZSI OUT	ZSI modules of lower fault zone circuit breakers
MV OUT	Signal to specific Siemens medium voltage circuit breakers

ZSI CubicleBUS Module Settings

OFF	ZSI function is deactivated
S	ZSI module only effective for short-time delay short circuit
G	ZSI module only effective for ground fault protection
S + G	ZSI module effective for short-time delay short circuit and ground fault protection
TEST	Test position for testing the ZSI functionality

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INTERNAL TESTING PROCEDURE

The integrated test feature of the ZSI CubicleBUS module (rotary coding switch in the TEST position) makes it possible to check the ZSI wiring and the functionality of the ZSI module electronics. See Figure 4 below for a list of the module LEDs and color code.

The outputs are set (a blocking signal is sent to other circuit breakers) when the rotary coding switch is set to "TEST" (the "OUT" LED will turn orange). This allows the inputs on ZSI modules on higher fault zone breakers to be checked (verify that they become active) for correct wiring. Pressing the "TEST" button switches the ZSI module to test mode, which is indicated by the orange "DEVICE" LED. After a pause of at least 2 seconds, press the "TEST" button. The "G" LED will turn orange, verifying its functionality. After another 2 seconds, press the "TEST" button again. The "IN" LED will now turn orange. After another 2 seconds, press the "TEST" button again. The "S" LED will now turn orange. After another 2 seconds, press the "TEST" button again. The "OUT" LED will now turn orange. After another 2 seconds, press the "TEST" button again. All of the LEDs will now turn orange. Hitting the test button again will reset the ZSI module back to its original state.

Device LED	
	Internal fault in the ZSI CubicleBUS module.
	ZSI CubicleBUS module is in test mode.
	ZSI CubicleBUS module is in operation.
CubicleBUS LED	
	Connection exists to an additional CubicleBUS module.
	No other CubicleBUS module has been detected
G and S LEDs	
	The ZSI CubicleBUS module is in S and/or G mode.
	The ZSI CubicleBUS module is not in any mode.
IN and OUT LEDs	
	The input and/or output is active.
	The input and/or output is inactive.

Figure 4. ZSI CubicleBUS Module LED Indicator Information

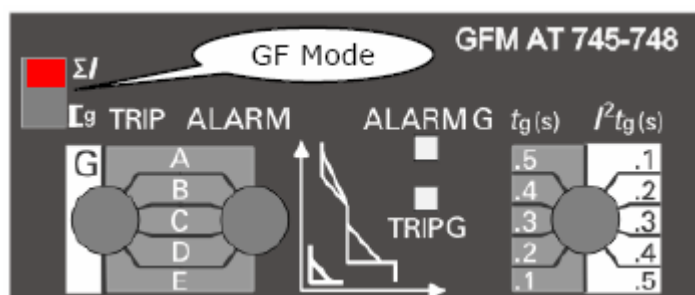
PRIMARY INJECTION TESTING PROCEDURE

The following test procedure is to be performed with the rotary switch on the Zone Selective Interlock CubicleBUS modules set to the "G" position. A similar procedure can be used for the "S" mode, however, current levels will need to be adjusted upward according to the short time pickup levels of each circuit breaker and the ground fault protection will have to be disabled on each breaker (or the current injected on one phase will have to be sent back through a different phase to zero the vector summation of the two phases). This procedure is to be used only with breakers that utilize 3 or 4-wire residual ground fault type systems. Typically only main circuit breakers utilize the direct sensing ground fault method which will not effect the testing of the zone selective interlocking system.

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Before beginning to test, the ground fault mode setting must be verified. For all breakers in fault zone 2 or below, the ground fault mode switch must be in the summation (top) position (see illustration of the ground fault module below) for a 3 or 4-wire residual ground fault system. In this mode, the ETU will perform a vector summation of phases A, B, C and if connected, N. If this sum is not zero or close to it, a ground fault is present and the ETU behaves according to the pickup and delay settings.

NOTE: For an ETU776 trip unit, the mode is set via the keypad on the front of the trip unit (there is no physical switch). For an ETU755 trip unit, the mode must be set with a BDA/BDA plus or via Profibus or Modbus communication interface.



Make sure that the short time delay is not set to the 20ms setting. In this position, a phase-loss sensitivity function is enabled. When active and the trip unit detects that the least heavily loaded phase is 50% lower than the most heavily loaded phase, the long-time pickup setting is reduced to 80% of setting indicated on the display or dial. When this unbalance condition no longer exists, the setting is returned to normal.

Referring to Figure 2 as a typical zone selective interlocking system, a current higher than the ground fault pick-up of the main breaker will be injected through phase B of the circuit breaker directly upstream of the fault to simulate a ground fault condition at that location. The setting of each of the breakers shall be as shown in Figure 5.

ZONE	GROUND FAULT DELAY (S)	GROUND FAULT TRIP
1	0.3	A
2	0.4	A
3	0.5	A

Figure 5. WL Circuit Breaker Test Settings

The A setting for ground fault pick-up corresponds to 100A for frame size I and II circuit breakers, 400A for frame size III circuit breakers. Complete the following steps to completely test the zone selective interlock system.

- 1) For the Zone 3 circuit breaker, inject 500A of current through the B phase only using the line and load terminations as the connecting points. Current should flow in the direction from the line side of the breaker to the load side of the breaker. The Zone 3 breaker should trip in 50ms, blocking signals should be sent to the upper fault zone breakers (an

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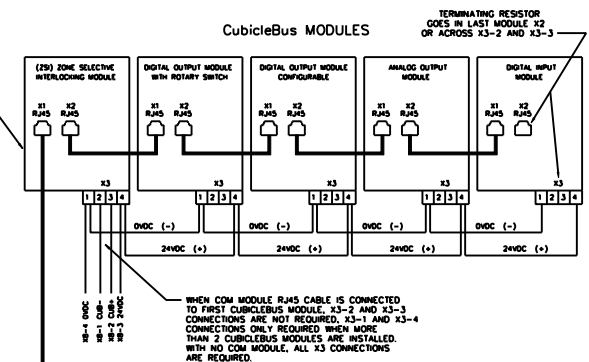
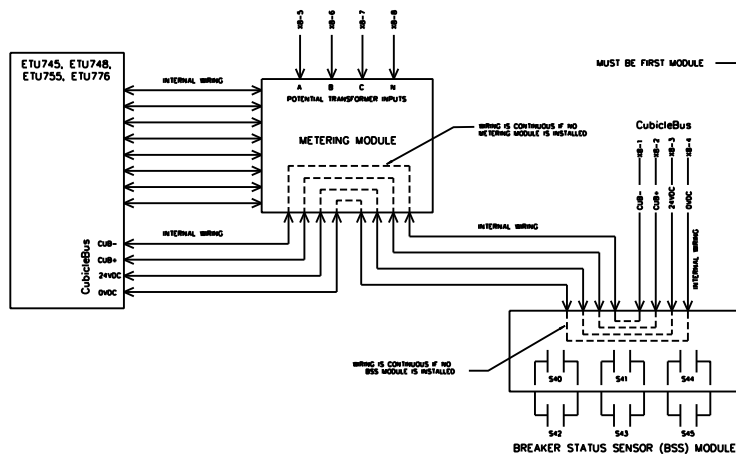
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additional person can view the “OUT” LED indicator on the Zone 3 breaker and the “IN” LED indicators on the Zone 1 and 2 breakers, test may have to be run several times depending on how many assistants are available). Even though the time delay is higher (0.5 seconds) for the Zone 3 breaker, it will trip first when zone selective interlocking is applied. This same step can be performed for any other breakers in Zone 3 that are connected to upstream breakers.

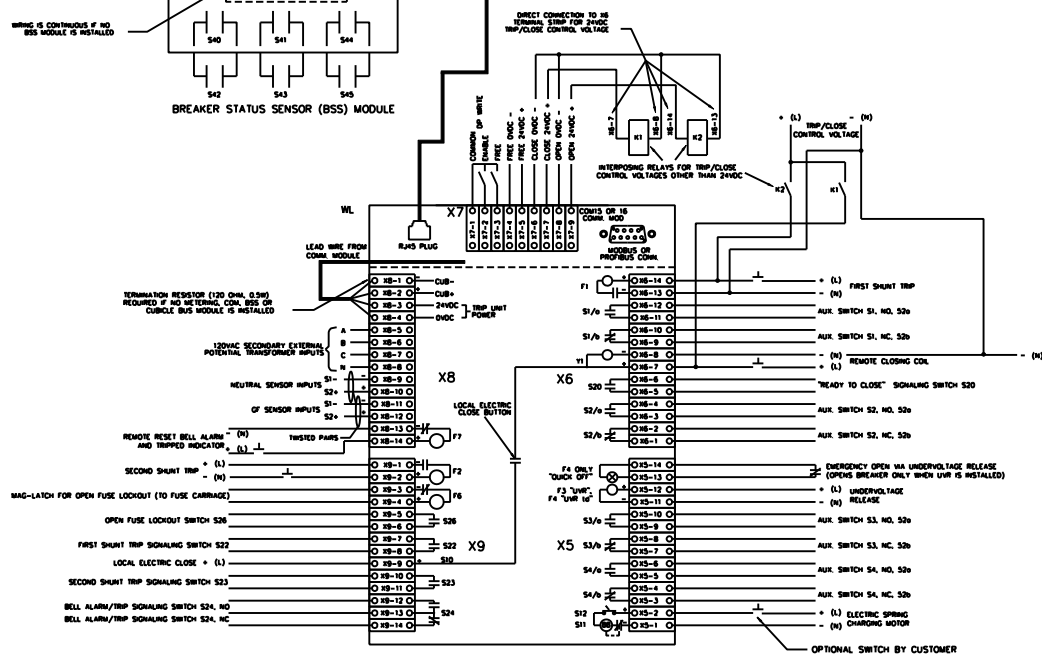
- 2) For the Zone 2 circuit breaker, inject 500A of current through the B phase only using the line and load terminations as the connecting points. Current should flow in the direction from the line side of the breaker to the load side of the breaker. The Zone 2 breaker should trip in 50ms, a blocking signal should be sent to the upstream Zone 1 breaker (an additional person can view the “OUT” LED indicator on the Zone 2 breaker and the “IN” LED indicator on the Zone 1 breaker, test may have to be run several times depending on how many assistants are available). The Zone 3 breaker should not trip. Even though the time delay is higher (0.4 seconds) for the Zone 2 breaker, it will trip first when zone selective interlocking is applied. This same step can be performed for any other breakers in Zone 2 that are connected to a Zone 1 upstream breaker.
- 3) For the Zone 1 circuit breaker (if using 3 or 4-wire residual ground fault sensing), inject 500A of current through the B phase only using the line and load terminations as the connecting points. Current should flow in the direction from the line side of the breaker to the load side of the breaker. The Zone 1 breaker should trip in 50ms instead of 0.3 seconds. This same step can be applied for any other Zone 1 breakers that feed downstream breakers.

NOTE: If the Zone 1 circuit breaker utilizes direct ground fault current sensing, the ground fault mode will have to be changed to direct mode. Approximately 100A will have to be run through B phase (from line to load side) from a secondary current source to energize the trip unit. The primary test current will have to be injected through the external GF sensor to provide a ground fault trip of the Zone 1 circuit breaker.

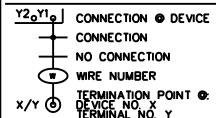
BREAKER WIRING SCHEMATICS



— WHEN COM MODULE RJ45 CABLE IS CONNECTED TO FIRST CUBICLEBUS MODULE, X3-2 AND X3- CONNECTIONS ARE NOT REQUIRED, X3-1 AND X CONNECTIONS ONLY REQUIRED WHEN MORE THAN 2 CUBICLEBUS MODULES ARE INSTALLED. WITH NO COM MODULE, ALL X3 CONNECTIONS ARE REQUIRED



SCHEMATIC LEGEND



NS - SIEMENS AIR-CORE NEUTRAL SENSOR
WL - WL CIRCUIT BREAKER; SIEMENS ENERGY & AUTOMATION
GF - GROUND FAULT TRIP UNIT

1. COMPONENT PLACEMENT PER PANEL, SWITCHGEAR, OR SWITCHBOARD DRAWINGS.
2. ALL DEVICES SHOWN IN OPEN AND/OR DE-ENERGIZED STATE.
3. ALL GROUND FAULT WIRING TO BE TWISTED PAIR

CUB+ = CUBICAL BUS DATA	S3/0 = AUX SWITCH 3 "NO"
CUB+ = CUBICAL BUS DATA	S3/1 = AUX SWITCH 3 "NC"
F1 = 1st SHUNT TRIP	S4/0 = AUX SWITCH 4 "NO"
F2 = 2nd SHUNT TRIP	S4/1 = AUX SWITCH 4 "NC"
2nd AUX RELEASE	S10 = LOCAL ELECTRIC MOTOR
F3 = "VVR"	S11 = CHARGING MOTOR - MOTOR CUT-OFF SW
F4 = "VVR WITH TIME DELAY"	S12 = SPRING CHARGING MOTOR
F4 = EMERGENCY "QUICK OFF"	S20 = "READY TO CLOSE" SIGNALING SWITCH
F6 = MAG-LATCH FOR OPEN FUSE	S22 = SIGNALING SW 1st AUX RELEASE
LOCKOUT (F5 IS FUSED ONLY)	S23 = SIGNALING SW 2nd AUX RELEASE
F7 = REMOTE RESET BELL ALARM	TRIP SIGNALING SWITCH
AND TRIPPED INDICATOR	S26 = SIGNALING SW OPEN FUSE LOCKOUT
S1+ = AIR-CORE NEUTRAL SENSOR	S40 = BSS SIGNALING SWITCH "READY TO CLOSE"
S2+ = AIR-CORE NEUTRAL SENSOR	S41 = BSS SIGNALING SWITCH SPRING CHARGED
S1/0 = AUX SWITCH 1 "NO"	S42 = BSS SIGNALING SW 1st AUX RELEASE
S1/1 = AUX SWITCH 1 "NC"	S43 = BSS SIGNALING SW 2nd AUX RELEASE
S2/0 = AUX SWITCH 2 "NO"	S44 = BSS TRIP SIGNALING SWITCH
S2/1 = AUX SWITCH 2 "NC"	S45 = BSS TRIP SIGNALING SW OPEN/CLOSE POSITION
	S46 = SIGNALING SWITCH CONNECTED POSITION
	S47 = SIGNALING SWITCH TEST POSITION
	S48 = SIGNALING SWITCH DISCONNECTED POSITION
24VDC TRIP UNIT POWER FROM CLASS 2 POWER SUPPLY	X1 = IRON-CORE MOGF SENSOR
	X2 = IRON-CORE MOGF SENSOR
	X1 CLOSING COIL

Date	Unless otherwise specified dimensions are in inches		Confidential - Property of Siemens Energy & Automation, Inc. Electrical Apparatus Division
	Tolerances are non-cumulative and are as follows unless specified otherwise: xxx .030 xxx .015 Angular .2° Do not scale drawing		
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